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INTERIOR CORROSION OF STEEL STRUTS AND ITS PREVENTION

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INTERIOR CORROSION OF STEEL STRUT TUBING AND ITS PREVENTION.

PURPOSE.

To investigate the necessity of protecting from corrosion the interior of airplane parts manufactured from steel tubing, and also to develop a suitable method for cleaning and coating the interior of these parts.

CONCLUSIONS.

It was found to be very desirable to protect the interior of steel tubing.

The inside of the tubing should be thoroughly cleaned before any protective coating is applied. The best method is pickling, followed by immersion of the part in a weak soda solution, thoroughly rinsing in hot water and drying with an air blast. The pickling solution recommended is a 5 per cent sulphuric acid, steam heated. This method can only be followed when both ends of the tube are open, and should be used only when other methods have failed to give a clear interior surface. When it is impracticable to pickle and the ends are open, the use of a wire brush is recommended. The tubing should be thoroughly cleaned and dried before it is assembled into the structure.

After cleaning, the inside of the tube should be protected by a liquid primer of the following composition:

	Per cent.
Liquid	45
Pigment	55

The following formula is recommended:

	Per cent.
Liquid:	
Raw linseed oil	70
Drier and turpentine	30
Pigment: Indian red (90 per cent Fe_2O_3).	100

This liquid should be applied after all welding, brazing, and other operations involved in the fabrication of the part from the tubing.

When the ends are closed, the pigment mixture should be forced in under air pressure and allowed to drain from the other end of the tube.

The weight of one coat of the metal primer is less than 1 ounce per square foot.

Zinc plating gave the best results as far as durability alone is concerned, but in many cases zinc can not be applied to the interior of tubular parts.

When the tubes are zinc plated on the exterior, the interior should be thoroughly washed with warm water, drained, and dried with an air blast after plating.

Such compounds as "No-Oxide A" and "Rust Veto Heavy" gave good results, but were too thick to apply to small tubular members.

MATERIAL.

The following material was used as coatings for the inside of metal struts:

1. Zinc plating..................Chemistry branch.
2. Linseed oil primer............Chemistry branch.
   - Liquid......................45 per cent.
   - Pigment.....................55 per cent.
     - Liquid:
       - Raw linseed oil.....70 per cent.
       - Drier and turpentine. 30 per cent.
     - Pigment: Indian Red (90 per cent Fe_2O_3).......100 per cent.
3. Varnish primer................Chemistry branch.
   - Liquid......................45 per cent.
   - Pigment.....................55 per cent.
     - Liquid:
       - Spar varnish.........70 per cent.
       - Drier and turpentine. 30 per cent.
     - Pigment: Indian Red (90 per cent Fe_2O_3).......100 per cent.
4. Rust preventive V. D. 1536.....Patton Pitcairn Paint Co., Milwaukee, Wis.
5. Blue steel wire lacquer.........Pratt & Lambert (inc.), Buffalo, N. Y.
6. Valspar varnish..............Valentine & Co., New York City.
7. Aluminum enamel............Valentine & Co., New York City.
8. Baking varnish V-811...........Lowe Bros., Dayton, Ohio.
9. No-Oxide A.......................Dearborn Chemical Co., Chicago, Ill.
10. Rust Veto Heavy...............E. F. Houghton & Co., Philadelphia, Pa.

METAL.

1. Steel struts from stock at McCook Field, Dayton, Ohio.

METHOD OF PROCEDURE.

Coated and uncoated samples of tubing were exposed to atmospheric conditions and the rate of corrosion was noted. The tubing was first cleaned, washed and dried, and then coated on the outside with zinc plating, excepting No. C 1 and 2. They were exposed uncoated both inside and outside.

The coatings were applied by pouring them in the tubes and then draining in an upright position.

The following methods and solutions for cleaning the inside of the tubes were tried:

a. Vasoline oil.................. 4 parts.
Turpentine.................. 1 part.
Naphtha.................... 1 part.
Rubbed with a brush and washed with benzol and then dried thoroughly.

b. Kerosene.................... 2 parts.
Sperm oil.................... 1 part.
Turpentine.................. 1 part.
Acetone.................... 1 part.
Blown dry with air at 120 pounds pressure.

c. Stannic chloride............ 100 g.
Water...................... 1,000 c. c.
Tartaric acid................ 2 g.
Water...................... 1,000 c. c.

d. Immersed tubes in kerosene. Immersed in benzol, drained, and then dried thoroughly with air blast at 120 pounds pressure.

e. Immersed tubes in dilute sulphuric acid (10 per cent solution), washed with hot water, and dried.

f. Immersed tubes in 50 per cent hydrochloric acid and 10 per cent formaldehyde, washed and dried.

g. Immersed tubes in steam heated 5 per cent sulphuric acid, washed in weak soda solution, thoroughly rinsed in hot water, and dried with air blast.

Grease spots were removed with commercial benzol. Dirt was removed with hot water and then blown dry with an air blast.

RESULTS.

See Tables 1 and 2, also figures 1, 2, and 3.

DISCUSSION OF RESULTS.

Organic coatings will not adhere to greasy, dirty, or rusty metal surfaces, but will flow around the uncleaned spots, which later become starting points for rust. There may also be a progression of the corrosion from the rust under the coating, therefore this rust must be removed to insure good results.

It is very difficult to obtain tubing that is not rusted or dirty when received, because in shipping some moisture collects on the inside of the tubing. It is practically useless to coat over this rust, and some method of cleaning the inside of the tubing before coating should be used. The grease should first be removed with either benzol (90 per cent) or such commercial cleansers as Oakite, etc., then the dirt and rust can best be removed in a hot 5 per cent sulphuric-acid solution. (This method should be followed only by those who are experienced in pickling steel.[1] The tube should then be washed with hot water and thoroughly dried by means of an air blast of about 100 pounds pressure. This should be done before the ends of the tubes are closed. After the tubes are closed, a hole about one-eighth of an inch in diameter should be left in each end of the tubing so that the coating may be poured in and drained out. A coating of an iron oxide metal primer (B–1) will insure protection to the inside of the tubing. Where possible the inside of the tubing should be brushed with a wire brush. This will help to remove most of the rust.

The primer is recommended in preference to the grease compounds such as No-Oxide A and Rust Veto Heavy because they were too thick to apply through a one-eighth inch hole. It might be suggested that these compounds be thinned, but previous exposure tests have indicated that the thin coatings do not give as great a protection as do the thick ones.

The cleaning compounds, such as "*a*," "*b*," and "*c*" are rather expensive and the results were no better than those obtained by use of benzol and sulphuric-acid cleaning solutions. While the iron oxide primer in the series of tests just competed gave the best results, other experimenters have found that a primer made of red lead or graphite will give results as good as iron oxide. These pigments gave good results both for adhesion and for minimum deterioration of film and minimum corrosion underneath the film. It is interesting to note that in the tests conducted by the paint manufacturers' association,[2] the vehicle recommended was raw linseed oil similar to that used in the iron oxide primer.

The pigment used in the iron oxide primer is Indian red. Indian red is a natural hematite or Persian Gulf ore. Only those ores having the proper shade are selected and termed "Indian red." The term "Indian red" is also applied sometimes to artificial iron oxides made by calcining copperas. These pigments generally contain from 90 to 95 per cent oxide of iron, with varying percentages of silica. The natural iron oxides made from hematite ores, some of which are termed "bright red oxide" and "Indian red," have a gravity of 3.5 to 5.2 and grind in about 20 to 25 per cent of oil. The natural iron oxides make valuable body pigments for inhibitive paints.

Though graphite gave good results in the tests conducted by the paint manufacturers' association, there are some objections to its use as an inhibitor. There are two forms of graphite, namely, the natural and the artificial. These contain varying amounts of carbon mixed with silica and sometimes iron oxide. The percentage of carbon is usually over 90.

Both forms of graphite have been used extensively as coatings for steel and iron, but, due to the excessive spreading of the paint, the paint film is very thin and sometimes does not afford as great a protection as is desired. For this reason graphite paints are mixed with heavier pigments. However, it is not considered a good inhibitor on account of the ease with which it conducts electric currents.

Red lead is a very heavy, brilliant red pigment, and is made by further oxidizing litharge (lead oxide). It, along with iron oxide, is considered one of the best pigments known for the protection of steel and iron. The one objection to red lead is the stiffness of the resulting paint. This would mean that the red-lead paint is very thick and heavy, which would be an objection to the use of red lead in aircraft construction.

[1] The tubes should remain in the pickling solution for about 10 minutes.

[2] Corrosion and Preservation of Iron and Steel, by Cushman and Gardner.

Table No. 1.—*Interior coatings for metal struts after 401 days exposure.*

No.	Name and description.	Company.	Exposed.	June 4, 1921		September 1, 1921		May 12, 1922	
				Outside.	Inside.	Outside.	Inside.	Outside.	Inside.
A1–o	Zinc plating	Chemistry branch	April 6, 1921	O. K.	O. K.	O. K.	O. K.	O. K.	O. K.
A2–c	do	do	do	O. K.	O. K.	O. K.	Sl cor.	O. K.	3%
B1–o	Raw linseed oil and Indian red	do	do	O. K.	O. K.	O. K.	O. K.	O. K.	O. K.
B2–c	do	do	do	O. K.	O. K.	O. K.	Sl cor.	O. K.	5%
C1–o	No coating	do	do	100	90	....	100	....	....
C2–c	do	do	do	100	95	....	100	....	....
D1–o	Rust preventive V. D. 1536	Patton - Pitcairn, Milwaukee, Wis.	do	O. K.	O. K.	O. K.	O. K.	O. K.	10%
D2–c	do	do	do	O. K.	3%	O. K.	10%	O. K.	40%
E1–o	Spar varnish and Indian red	Chemistry branch	do	O. K.	O. K.	O. K.	O. K.	O. K.	O. K.
E2–c	do	do	do	O. K.	O. K.	O. K.	10%	30%	40%
F1–o	Blue lacquer No. 3729	Pratt & Lambert Co., Buffalo, N. Y.	do	O. K.	O. K.	O. K.	O. K.	O. K.	O. K.
F2–c	do	do	do	O. K.	2%	O. K.	20%	O. K.	50%
G1–o	Valspar varnish	Valentine & Co., New York City.	do	O. K.	O. K.	O. K.	O. K.	O. K.	5%
G2–c	do	do	do	O. K.	O. K.	O. K.	5%	O. K.	10%

Note.—o=open; c=closed.
Outside zinc plated except C1 and 2.
The closed tubes were saturated with salt water, then closed.
The increased corrosion of E2–c, spar varnish and Indian red, over that of G2–c, straight spar varnish, was due to the fact that the tube E2–c blew off the rack during a storm and was not replaced until after corrosion had started.

Table No. 2.—*Interior coatings for metal struts after 254 days' exposure.*

No.	Name and description.	Company.	Exposed.	October 30, 1921		May 12, 1922		Remarks.
				Outside.	Inside.	Outside.	Inside.	
H1–c	Aluminum enamel	Valentine & Co., New York City.	Sept. 1, 1921	O. K.	O. K.	O. K.	5%	200 c. c. water inside at time of inspection.
H2–o	do	do	do	O. K.	O. K.	O. K.	50%	
J1–c	Baking varnish V-811 (1 hour at 250° F.).	Lowe Bros. Co., Dayton, Ohio.	do	O. K.	O. K.	O. K.	5%	
J2–o	do	do	do	O. K.	O. K.	30%	7%	
K1–c	No-oxide A	Dearborn Chemical Co., Chicago, Ill.	do	O. K.	O. K.	O. K.	O. K.	Coating too thick for small tubes.
K2–o	do	do	do	O. K.	O. K.	O. K.	O. K.	
L1–c	Rust Veto Heavy	E. F. Houghton & Co., Philadelphia, Pa.	do	O. K.	O. K.	O. K.	O. K.	Do.
L2–o	do	do	do	O. K.	O. K.	O. K.	O. K.	
......	No coating on inside; outside zinc plated.	Chemistry branch	do	O. K.	100	....	....	

Note.—o=open tube; c=closed tube.
All tubes were zinc plated on outside.
The closed tubes were saturated with salt water, then closed.

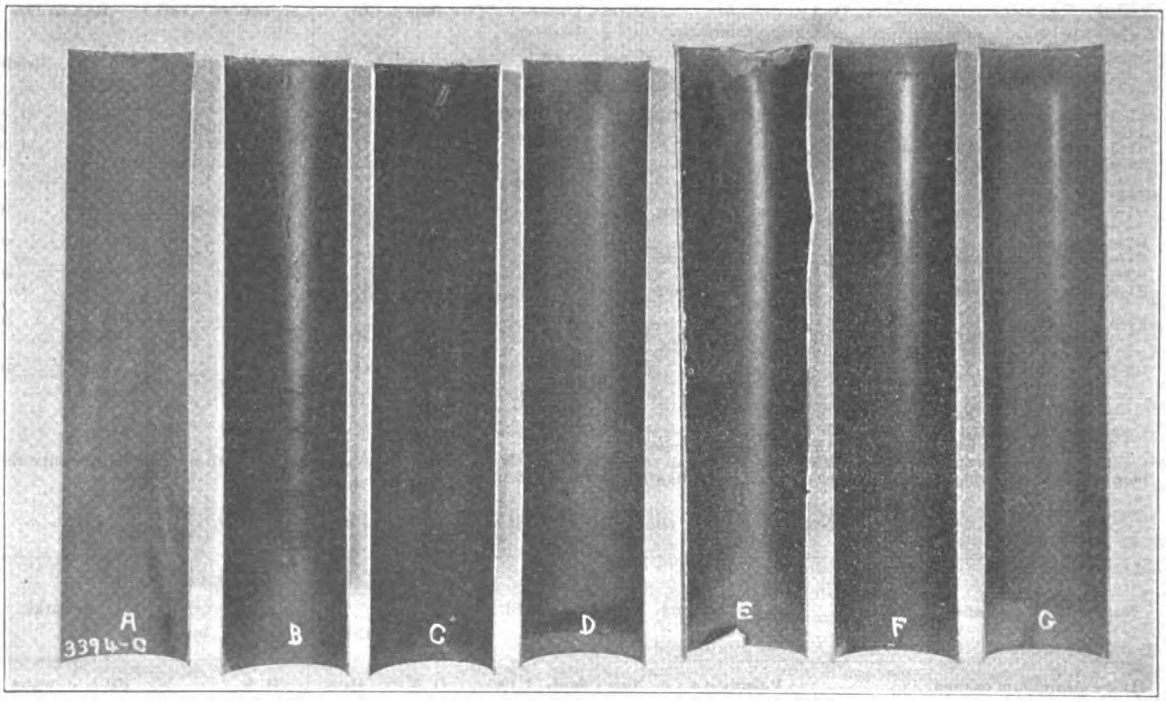

FIG. 1.—Section of metal tubing exposed 401 days. Open and exposed to the weather.

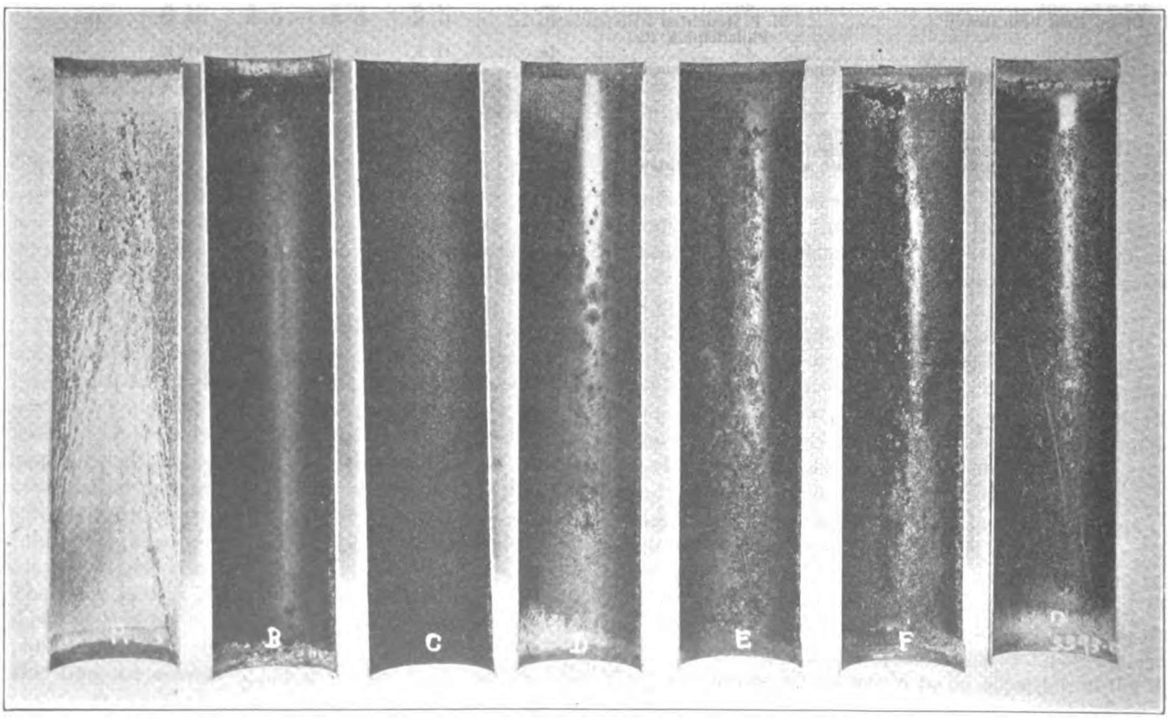

FIG. 2.—Section of metal tubing exposed 401 days. Closed and saturated with salt water solution.

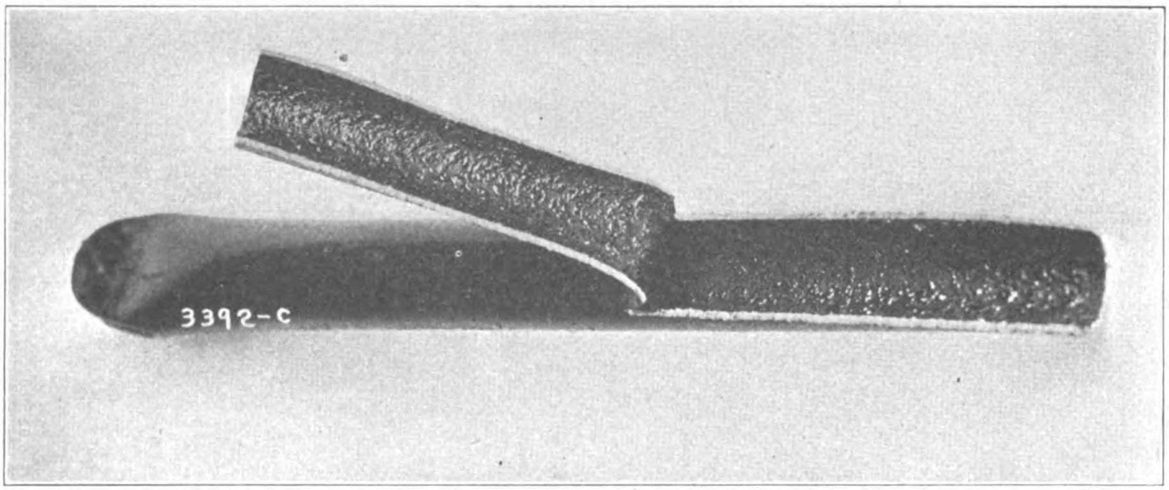

Fig. 3.—Service metal tubing. Outside coated. Inside uncoated. Showing the necessity of coating the interior.